

# **U.S. FISH AND WILDLIFE SERVICE**

## **Post-Delisting Monitoring Plan**

**for the Monito gecko**

**(*Sphaerodactylus micropithecus*)**



Photo by O. Monsegur - USFWS

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## **Anti-deficiency Act Disclaimer**

Post-delisting monitoring is a cooperative effort between the U.S. Fish and Wildlife Service, State governments; other Federal agencies, and nongovernmental partners. Funding of post-delisting monitoring presents a challenge for all partners committed to ensuring the continued viability of the Monito gecko following removal of protections afforded under the Endangered Species Act, as amended. To the extent feasible, the Service and our partners intend to provide funding for post-delisting monitoring efforts through the annual appropriations process. Nonetheless, nothing in this Post-Delisting Monitoring Plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation.

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## **I. Introduction**

Post-delisting monitoring refers to activities undertaken to verify that a species delisted due to recovery remains secure from risk of extinction after the protections of the Endangered Species Act (Act; 16 United States Code [U.S.C.] 1531 *et seq.*) are no longer necessary. A primary goal of post-delisting monitoring is to monitor the species to ensure the status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is identified, to enact measures to halt the decline so that re-proposing the species as threatened or endangered is not needed.

Section 4(g)(1) of the Act requires the Secretary of the Interior to implement a system in cooperation with the States to monitor effectively, for not less than 5 years, the status of all species that have recovered and been removed from the Federal List of Endangered and Threatened Wildlife and Plants (List). Section 4(g)(2) of the Act directs the U.S. Fish and Wildlife Service (Service) to make prompt use of its emergency listing authorities under section 4(b)(7) to prevent significant risk to the well-being of any recovered species. While not specifically mentioned in section 4(g), authorities to list species in accordance with the process prescribed in sections 4(b)(5) and 4(b)(6) may also be utilized to reinstate species on the List, if warranted.

The Service and States have latitude to determine the extent and intensity of post-delisting monitoring that is needed and appropriate. The Act does not require the development of a formal Post-Delisting Monitoring Plan (PDM). However, we generally desire to follow a written planning document to provide for the effective implementation of section 4(g) by guiding collection and evaluation of pertinent information over the monitoring period and articulating the associated funding needs. This document was prepared to describe the PDM for the Monito gecko (*Sphaerodactylus micropithecus*) and follows the Service's August 2008, *Post-Delisting Monitoring Plan Guidance Under the Endangered Species Act* (Service 2008).

## **II. Species Listing History**

On October 22, 1980, the Service proposed listing the Monito gecko as an endangered species and designation of Monito Island as critical habitat (45 FR 70192). On October 15, 1982, the species was listed as endangered with the entire Monito Island designated as critical habitat (47 FR 46090). The Monito gecko was listed because of the apparent extremely small population size coupled with suspected predation by rats. The recovery plan was finalized on March 27, 1986 (USFWS 1986). On November 6, 1991, a 5-Year Review for several species was completed with no species-specific, in-depth assessment of the five factors as they pertained to the different species' recovery (56 FR 56882). In particular, no changes were proposed for the status of the Monito gecko in that review. The next 5-year review was completed on August 8, 2016, in which the Service recommended delisting the species (USFWS 2016).

### **III. Summary of Cooperator Roles in the Post-Delisting Monitoring Planning Effort**

The Service prepared this PDM Plan with the technical assistance from the Puerto Rico Department of Natural and Environmental Resources (PRDNER). This plan is designed to detect significant declines in the Monito gecko population used to support delisting with reasonable certainty and precision. It meets the minimum requirement set forth by the Act by effectively monitoring the status of the Monito gecko using population sampling events and monitoring of threats for five years. The Service also requested comments during the public comment period to help us finalize this plan. The primary goal of this plan will be accomplished through cooperation with the PRDNER, other U.S. Federal agencies, non- governmental organizations, and individuals.

#### U.S. Fish and Wildlife Service

The Service is responsible for ensuring that effective post-delisting monitoring of the Monito gecko is accomplished through participation and oversight of all activities implemented with the PRDNER and other cooperators. Participation includes regular coordination with the PRDNER for the post-delisting monitoring activities and data analysis. The Service will also incorporate additional information on habitat trends and threats (as it becomes available during the monitoring period) that may aid in assessing the status of the Monito gecko. This PDM will build directly upon the 2016 population monitoring methods and data used during recovery as described in the population status report of the species (IC 2016) and the 5-year review (USFWS 2016).

#### Puerto Rico Department of Natural and Environmental Resources

The PRDNER was the principal party for the rat eradication efforts on Monito Island and in cooperation with the Service, provided the necessary support during the May 2014 and 2016 Monito Island trips. The PRDNER will be responsible for the continued management of the Mona/Monito Island Reserve and provide permits, and assistance during post-delisting monitoring surveys. The PRDNER will participate and collaborate in the post-delisting monitoring activities and provide comments on the results from data analysis.

### **IV. Summary of Species Status at the Time of Delisting**

#### **A. Background**

The Monito gecko (Schwartz 1977, entire) is a small lizard (approximately 36 millimeters (1.42 inches) snout-vent length) with an overall pale tan body and dark-brown mottling on the dorsal surface. It is closely related to the *Sphaerodactylus macrolepis* complex of the Puerto Rican Bank, but variation in dorsal pattern and scale counts confirm the distinctiveness of the species; probably resulting from a

single invasion to Monito Island and its subsequent isolation (Schwartz 1977, p. 990, Dodd and Ortiz 1984, p. 768).

Not much is known about the biology of this species, including its diet, reproduction, or potential predators. A study of the diet of other more common *Sphaerodactylus* species in Puerto Rico found a diverse content of small invertebrates, such as mites, springtails and spiders (Thomas and Gaa Kessler 1996, p. 347-362). Out of the 18 individuals counted by Dodd and Ortiz (1983, p. 120), they found juveniles and gravid females suggesting that the species is reproducing. Dodd and Ortiz (1983, p. 121) suspected reproduction occurs from at least March through November, as suggested by the egg found by Campbell in May 1974, by the gravid females found by Dodd and Ortiz (1983, p. 121) on August 1982, and the fact that Monito gecko eggs take 2 to 3 months to hatch (Rivero 1998, p. 89). During a plot survey on May 2016, two gravid females and several juveniles were found (USFWS 2016, p. 13). Potential natural predators of the Monito gecko may include the other native lizard *Anolis monensis* and/or the skink (*Spondylurus monitae*).

The Monito gecko is restricted to the island of Monito, an isolated island located in the Mona Passage, about 68 km (42.3 mi) west of Puerto Rico, 60 km (37.3 mi) east of Hispaniola and about 5 km (3.1 mi) northwest of Mona Island (USFWS 1986, p. 2). Monito Island is basically a flat plateau surrounded by vertical cliffs rising about 66 m (217 ft) with no beach, and considered the most inaccessible island within the Puerto Rican archipelago (García *et al.* 2002, p. 116). With an approximate area of 40 acres (c.a. 16 hectares) (Woodbury *et al.* 1977, p. 1), Monito Island is part of the Mona Island Reserve, managed for conservation by the PRDNER since 1986 (PRDNER, no date, p. 2). The remoteness and difficulty of access to Monito Island make studying the Monito gecko difficult (Dodd 1985, p. 2).

## **B. Habitat**

Monito Island continues to be managed by the PRDNER for conservation as part of the Mona Island Reserve (PRDNER, no date, p. 2). In 1940, the U.S. Government acquired Monito Island and the entire Island was used by the Air Corps/U.S. Air Force as a high-level radar bombing and gunnery range (PARSONS 2010, p. 2-5). In 1961, Monito Island was declared surplus and returned to the Commonwealth of Puerto Rico in September 1965 (PARSONS 2010, p. 2-5). The Monito gecko listing final rule (47 FR 46091) mentioned that, while Monito Island had been used in the past as a target for bombing practices and there were no plans to continue such practices at the time, any major alteration of Monito Island could be detrimental to the continued survival of the Monito gecko. In fact, the large amount of scattered debris on Monito Island suggests significant habitat modification from bombing activities (USFWS 1986, p. 5). However, information regarding historical effects of military operations on the species is not available. Assuming all past bombing activities occurred during the day, the most current information suggests the Monito gecko is mostly under shelter during the day. This behavior may have helped minimize direct bombing effects on the individuals.

The US Army Corps of Engineers (COE) completed a Monito Island site inspection on August 2009 (PARSONS 2010, entire). A qualitative reconnaissance and munitions constituents (MC) sampling was performed to confirm the range location and to evaluate the potential presence of munitions and explosives of concern (PARSONS 2010, p. ES-1). Although, unexploded ordnance (UXO) and munitions debris were found on Monito Island, the site inspection determined that immediate munitions removal actions were not warranted at that time and further sampling may be needed according to the evaluation.

The potential future UXO detonation activities may have an adverse effect on the Monito gecko and its habitat. The Service has been conducting informal consultation with the COE regarding their proposed UXO activities in order to develop species specific standard operating procedures (SOPs) for the Monito gecko and other federally listed species that occur on Monito Island. These site-specific SOPs would be considered the appropriate conservation measures required to avoid and minimize potential adverse effects on the species or its critical habitat. Since Monito Island is a natural reserve, all activities must be coordinated with the PRDNER. The PRDNER has stated that they will not allow detonation of any UXO on Monito Island. The Service also does not recommend any detonation on Monito Island. Other non-intrusive UXO cleanup activities could be implemented in the future.

Monito Island receives immigrants usually from the western islands of Cuba and Hispaniola while trying to enter U.S. territory. The PRDNER had mentioned that immigrants sometimes light fires on Monito Island in order to be detected and rescued. This information was documented during the May 2016 trip, where 2 recent fire pits were found. These were found on the south-southeast side of Monito Island close to the edge of the island on exposed rock. A small pile of fire wood cuttings was also found. The presence of fire pits on Monito Island had not been documented in the past. At least for the two fire pits found in May 2016, their placement and construction on exposed rock with little to no vegetation in the immediate vicinity, demonstrates these were controlled fires and their intention was not of criminal nature. Although there is no information available on the frequency and damage these fires may be causing, their potential effects may be considered low based on the fire characteristics previously mentioned. To date, there is no indication that any fire has spread throughout the Island.

### **C. Past and Current Population Size**

When the species' recovery plan was completed in 1986, only a couple of island-wide surveys had been completed (Dodd and Ortiz 1983, entire; Hammerson 1984, entire), with the highest count from Dodd and Ortiz (1983, p. 120) that reported a total of 18 geckos during a 2-day survey. All geckos found during both of these surveys were during the day and under rocks. Subsequent surveys of variable length and area covered detected from 0 to 13 geckos during the day as well



(PRDNER 1993, p. 3-4; USFWS 2016, p. 9). However, these surveys did not provide enough information to answer the population objectives in the Recovery Plan.

These previous attempts to survey for the Monito gecko are considered underestimates, because surveys were done during the day when the species is more difficult to detect since it seems to be less active and mostly hiding under rocks, debris, crevices or other substrates. Although geckos in the Sphaerodactylinae group are considered mostly diurnal or crepuscular (Rivero, p. 89; Pianka and Vitt 2003, p. 185; Thomas and Gaa Kessler 1996, p. 353), we suspected the Monito gecko is more active at night and thus easier to detect during night surveys. This was confirmed during a May 2014 rapid assessment and a May 2016 systematic survey. We found the Monito gecko is more difficult to detect during the day since it is mostly hiding under rocks, debris, crevices or other substrates.

During the May 2014 rapid assessment, at least one gecko was seen during each of the three nights of the trip, some were opportunistic encounters and others while actively searching for the species (USFWS 2016, p. 9). The greatest number of geckos observed during the May 2014 rapid assessment was 23 individuals. All observations were made after nightfall and none were seen during daylight hours. Geckos were seen on exposed substrates and not hidden under rocks or litter. Some were seen within leaf litter mixed with rocks under a *Ficus citrifolia* tree. Geckos were observed escaping into the cracks and solution holes of the limestone rock.

During May 2016, a systematic gecko survey was completed. Forty random plots were setup on Monito Island (USFWS 2016, p. 10). Each plot was 20 m x 20 m (400 m<sup>2</sup>), thus survey covered a total of 16,000 m<sup>2</sup> or approximately 11% of Monito Island. Four two-person teams visited 10 plots each. Each observer surveyed each plot independently. A total of 84 geckos were observed during 96 surveys among the 40 plots. All sites were surveyed at least twice and all took place during the night. Most geckos were found on exposed rock and only eight out of the 84 counted, were found under a rock or other substrate; all others were out and about during the night. Only two geckos were opportunistically found during the day while turning rocks and dry logs.

Gecko occupancy and abundance was estimated using a standard mathematical population model accounting for the abundance and detection bias that allow individuals to go unseen during surveys (IC 2016, p. 5). Occupancy of the geckos on Monito Island was 27.8 % (11.3 – 68.6 %). The estimated number of geckos per plot from the best fit model was 73.3 geckos (Range: 1 – 101). The abundance model indicates a total of 1,112 geckos present within the surveyed plots (95% CI: 362 – 2,281). Interpolated across the entire island, Monito Island hosts approximately 7,661 geckos (50% CI: 5,344 – 10,590). The interpolated zones represent the approximate number of geckos at any randomly selected 30 m<sup>2</sup> area (IC 2016, p. 6). Even though the species detections was low (1-8%), the Monito gecko abundance across Monito Island was estimated in the thousands, indicating a large and well-represented population (IC 2016, p.5-6).

#### **D. Residual Threats**

The May 2014 assessment and May 2016 systematic gecko survey encountered the highest number of geckos ever counted for the species, and geckos were widely distributed throughout the Island. Although there are no historical systematic surveys to determine population trends, the species has demonstrated resilient attributes (e.g. habitat generalist, potential high adult survival rate) for long-term persistence in the face of disturbance within a harsh xeric environment.

Factors believed to be responsible for the apparent rarity of the Monito gecko were rat predation, habitat alteration by U.S. Air Force aerial bombing practices on Monito Island after World War II, survey sampling design and difficulty of finding the species. The rat eradication campaign was the most important recovery action for the species completed in 1999 by the PRDNER. Recent rat surveys conducted in May 2014 and 2016 confirmed the absence of rats on Monito Island, 17 years after the rat eradication campaign. Although rat reinvasion seems unlikely, it cannot be disregarded. The Monito gecko may still potentially have some natural predation pressure from other native lizards on the island. However, the species has persisted despite potential predatory threats and there is no indication that the magnitude of an undetermined natural predation pressure is critical to the gecko's recovery or listing status.

Other potential future impacts to the species and its habitat (i.e., COE UXO inspection and cleanup activities, immigrants and public disembarking on the island, and fires) are considered low and non-imminent. Finally, the Monito gecko will remain protected under State laws and regulations within its protected habitat managed for conservation as a nature reserve.

#### **E. Management Commitments for Post-delisting Conservation**

The PRDNER has managed Monito Island as a natural reserve since 1986, protecting its wildlife and habitat. Monito Island not only harbors the Monito gecko, but also provides important habitat for one of the largest seabird nesting colonies in the Caribbean, in addition to other endemic and federally listed species like the Higo chumbo cactus (*Harrisia portoricensis*) and the Yellow-shouldered blackbird (*Agelaius xanthomus*). Thus, we expect that Monito Island will remain permanently protected as a nature reserve and managed for conservation by the PRDNER. In addition, there are no permanent residents on the Island and access is only allowed under special permits issued by the PRDNER, whom also maintain a Ranger detachment and biologist on nearby Mona Island.

The PRDNER will be the agency responsible for the Monito gecko management upon delisting. The Service in coordination with PRDNER will implement the PDM for at least 5 years. In addition, the PRDNER has a draft Mona and Monito Island Management Plan for the continued implementation of their management and conservation strategies of these Islands (PRDNER 2011, entire).

The Service and the PRDNER will assess the need to complete a Memorandum of Understanding or other type of agreement that will provide for the long-term protection and management of the species and Monito Island. Both agencies (PRDNER and USWFS) will continue to consult with the COE for the potential future UXO cleanup activities on Monito Island.

## **V. Monitoring Objective and Methods**

The two most important recovery actions for the species have been accomplished, that is, rat eradication and completion of a systematic gecko survey. Thus, the proposed methods herein would serve to monitor the species to ensure the status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is identified, to enact measures to halt the decline so that re-proposing the species as threatened or endangered is not needed.

Therefore, the focus of the PDM Plan for the Monito gecko will consist of two components: (1) population surveys for the gecko as proposed herein; and (2) rat presence/absence surveys.

### **A. Monito gecko Population Survey**

The following methods follow the strategy used during the 2016 Monito gecko survey (Island Conservation 2016). This survey was intended to study the species distribution and abundance in order to assess the status of the gecko. The method was designed for replication in order to monitor the species over time and to determine population trends and habitat preferences. A standard occupancy mathematical model was used, which provided the methods to estimate site occupancy, abundance, and density of animals that cannot be detected with certainty (Island Conservation 2016), especially given the cryptic nature of the Monito gecko.

Results from the 2016 Monito gecko survey indicated an abundance estimate of over 7,000 geckos across the entire Island, even with a low detection probability of 1-8% (Island Conservation 2016). Habitat covariates as recorded (i.e. % shrub cover, % herbaceous cover, % ground cover, % leaf litter, and % canopy cover) could not explain the differences in gecko detection or abundance across the plots.

The following information was obtained from the Island Conservation (2016) report.

1. *Survey teams:* We organized four 2-person teams (8 persons) to complete all components of the survey. Each team is assigned 10 survey sites and is responsible for marking the survey plots, collecting habitat data, and conducting gecko surveys. Monito Island was divided into four quadrants (southwest, northwest, northeast, southeast) each of which will be randomly assigned to a team.

2. *Survey site selection:* A total of 50 survey points were computed using a geographically random method in ArcGIS. Of these, a total of 40 survey points (10 per quadrant) were selected and located on the island (on average  $\pm 3$  m) using a handheld GPS unit pre-programmed with the geographic coordinates of each survey point. Each 2 person team is provided with a map and GPS coordinates to all of the 40 survey points (Appendix A).
3. *Marking plots and habitat data collection:* At each survey point, a 20 m x 20 m survey plot (400 m<sup>2</sup>) is marked by using the survey point as the southwest corner of the plot. The boundaries of each plot were marked every 10 m with flagging tape. Plots were marked and habitat data collected by teams during the afternoon of May 5, 2016 and early morning of May 6, 2016. To improve sampling efficiency, especially when sampling at night, we recommend that surveys should consider marking plots more visibly such as with reflective flagging or neon colored or reflective twine to mark the entire boundary of the plot.

Once plots are marked, each team records habitat covariates in each plot: % shrub cover (woody plants under 2 m tall), % herbaceous cover (grasses and sedges), % ground cover (exposed rock or soil cover), % leaf litter, and % canopy cover (trees taller than approximately 1.8 m (6 ft)). Because we were using the habitat variables for predictive models, we tested for collinearity among each covariate across the sites. Ground cover was collinear with shrub cover ( $r = 0.98$ ), and so only shrub cover is summarized and used in the remainder of this report.

4. *Gecko surveys:* Plots were surveyed across two nights on May 6 and 7, 2016, between 1900 h and 0100 h. Each observer will record the number of geckos detected, time, age class, general behavior, habitat found, and GPS coordinate. Weather conditions (skies, temperature (degrees Fahrenheit), % relative humidity, average and maximum wind speed (mph)) were recorded by one person at the beginning and end of each gecko survey night using a Kestrel 3000 hand-held weather meter. Refer to Appendix B for example data sheets.

As previously described, a total of 40 sampling plots (Appendix A) are marked by the teams. Teams arrive at their first sampling plot before nightfall and start the survey just after nightfall (after 7PM). The four teams of observers work in pairs. Each team decides on the order of sampling their 10 plots before the first survey begins. Team members sample their plots independently from each other. During surveys, teams considered the following:

- In order to avoid and reduce bias team members do not observe each other while sampling and no information about gecko detections is shared between team members until both observers have completed their sampling of a single plot.

- Each plot is sampled in the same manner by both observers, pre-determined within each team before sampling started. For example, plots are sampled using a standard pattern, when possible.
- Each observer records the start and finish sampling times for each plot.

Teams apply one of either two sampling scenarios: switched-plot sampling or sequential-plot sampling where plot A and plot B are any given plot.

- Switched-plot sampling*: One team member starts sampling in plot A while the second member starts in plot B. Once each observer has completed their count within their own plot, they switch plots. Once completed, both observers continue to the next pair of plots until all 10 plots are sampled by each team member. Each team member waits until sampling is completed in both plots (A and B) before switching. Thus, each team member independently samples all 10 plots within their quadrant. Most teams used the first option.
- Sequential-plot sampling*: One team member samples plot A while the second member waits until the sampling is completed. The second observer member is not allowed to observe the first observer during sampling. The first observer notifies the second observer when plot A is completed. The second observer then samples plot A while the first observer moves to plot B to begin sampling. The same sequence is implemented for the remaining plots. However, for the remainder of the plots, the second observer usually does not have to wait for the first observer to finish its plot. Once the second observer arrives to, for example, plot B, the first observer is already done or just finishing sampling its plot. Thus, each team member would independently sample all 10 plots within their quadrant.

All 40 plots are surveyed twice on the first night. The only plots re-surveyed on the second night, are those in which geckos were not detected. The same survey protocol for the first night is followed. The observer walks quietly at a slow pace within the plot and records the time and location of each gecko's detection.

Search effort for each plot is estimated from the start and end time of each survey (Island Conservation 2016). Mean search time per survey in 2016 was 25.8 minutes (N=96, SD  $\pm$  8.12 minutes, range 12-55 minutes). The time invested in each plot will be influenced by the complexity of the topography, the vegetation cover density and the presence of seabird nests.

During the 2016 survey, most second surveys were started almost immediately following completion of the first survey. However, no effect was found between first and second surveys. Yet, we still suggest that the treatment of samples as having independent survey histories may not adequately account for effect of plot disturbance caused during first survey. For future surveys, we

recommend that field methods are adjusted so all surveys occur within adequate time for the animals to acclimate and resume activity. In order to improve the probability of detection, we recommend that a standardized search effort per plot is maintained at a rate of 25-30 minutes per survey (IC 2016). Data was entered onto paper forms in the field, and transferred into an electronic data format (Excel) (refer to Appendix B for example data sheets).

5. *Opportunistic observations*: Gecko detections outside of sample plots are also recorded while observers walked between plots and the same data was collected (date, time, location). However, these observations are not included for the actual population analysis.
6. *Population analysis*: The data is formatted for analysis using each plot sample as a separate survey history. The R package ‘unmarked’ version 0.10.2 provides methods to estimate site occupancy, abundance, and density of animals that cannot be detected with certainty (Fiske and Chandler, 2011). The occupancy of the island by Monito geckos is fit with a model described by Mackenzie *et al.* (2002) and implemented with the function ‘occu’ where the occupancy and detection of the observed geckos is described by a Bernoulli process.

The abundance ( $N_i$ ) of the gecko on Monito Island was estimated using a  $N$ -mixture model with a negative binomial distribution for overdispersed data ( $\alpha$ ). Because the species is cryptic, surveys were likely to result in many absences, and the negative binomial distribution represents a zero inflated dataset (Johnson *et al.* 1992). Multiple models were fit with each combination of covariates was fit using the function ‘pcount’ (Royle 2004; Kéry *et al.* 2005) according to the equation  $y_{ij} \sim \text{Binomial}(N_i, p_{ij})$  where the mean of the negative binomial distribution is  $\lambda_i(1 - \psi)$  and the covariates describing the abundance and detection  $p_{ij}$  were transformed with a logit link. *Assumption: the surveys will yield many absences.*

The null model did not include any covariates and the universal model included all predictor covariates (canopy cover, leaf litter, shrub cover, and herbaceous cover). Each combination of model was analyzed for the optimal amount of parameters to fit the data using an Akaike’s Information Criterion (wAIC) approach. The model with the lowest AIC represents the most representative model of the dataset. *Assumption: the data is best explained by the simplest number of parameters (i.e., Occam’s razor).*

To test the fit of the best ranked models the data well, a parametric bootstrap sampling from the function ‘parboot’ was used. The function ‘parboot’ uses the model object previously fitted in ‘pcount’ to refit the model iteratively and test for goodness-of-fit (GOF). We specified a Bayesian posterior test of the latent abundance which allows us to compare the modeled abundance to distributions simulated from the fit model. The bootstrap  $P$  value for the models was run 1,000 times; a non-significant value ( $P > 0.05$ ) suggests the model estimate has

an appropriate GOF. The final model was examined to find the abundance ( $N$ ) and detection  $\psi$  for each site. *Assumption: the simplest model will have a mathematically convergent solution.*

The final model estimates for each site were used as a dataset to fit a geographic linear interpolation across the 14.5 ha island using a 30 m<sup>2</sup> grid based on the pixel size of the GIS data available (Gould *et al.* 2008). The overall method was developed for use with terrestrial low detection species and previously peer-reviewed (Angeli *et al.* 2018; Fitzgerald *et al.* 2015). *Assumption: the survey plots are representative of the island.*

Please refer to the 2016 survey report for more information (Island Conservation 2016). The population surveys, following the methodology in 2016 survey report should be ideally conducted every other year to identify trends.

## **B. Rat Survey**

Black rats (*Rattus rattus*) were first documented on Monito Island in June 1969 and described to occur in large numbers over the entire island and active at all hours (Kepler 1978). During a survey trip in 1974, Dr. Howard W. Campbell reported a dense population of introduced rats and describing that “one is never out of sight of at least one foraging rat and frequently several will be in sight at any given moment...” (Dodd and Ortiz 1983). Subsequent visits to Monito Island also noted an abundance of rats on the island (Kepler 1978, Dodd and Ortiz 1983, Hammerson 1984).

On October 1992, the PRDNER began an eradication/survey program for black rats on the island (García *et al.* 2002). Back then biologists used snap traps and chew blocks (soft wood pieces soaked in canola oil) to assess changes in the rat population while using a rodenticide. Since the completion of the second poisoning campaign (August 1999), no rats have been detected on Monito Island. García *et al.* (2002) concluded that in order to be certain that eradication has been achieved, it is essential that the appropriate rat monitoring continues on Monito Island, especially using chew blocks. During a seabird blood sampling trip in August 2000, Anderson and Steeves (2000) reported not seeing any rats, as did subsequent PRDNER bird survey trips in 2003. However, no systematic rat monitoring on Monito Island has taken place since September 1999. The Service and the PRDNER conducted rat surveys during May 2014 and 2016 and neither detected rats.

During the May 2014 rat survey, a total of 27 snap traps and 70 chew blocks were used. Snap traps were fixed on wooden stakes and positioned over the substrate so the trap would remain firmly in place and minimize trapping land crabs (Figure 1A). Chew blocks were attached using plastic tie wraps (Figure 1B). Chew blocks were made with corrugated plastic sheet cut into small squares and filled with bait. We used a mixture of peanut butter and oatmeal as bait for the snap traps. For

chew blocks, we followed a peanut butter batter recipe (peanut butter, flour, and sugar) provided by IC. Baited chew blocks allow rats to chew on the plastic, thus marking the plastic with their characteristic bite marks. In addition, we intentionally left out food items within the camp area to have an additional rat detection alternative. We distributed all snap traps and chew blocks along the island using transects (Appendix C) similar to those used by García *et al.* (2002). If rats were present, we would expect detection either by capture on the snap traps, by bite marks on the chew blocks or leftover food items. All snap traps and chew blocks were left *in situ* for two nights.



Figure 1. Examples of snap trap (A) and chew block (B) placement.

During the May 2016 trip, we decided to use only the chew blocks. We placed a total of 80 chew blocks, two within each gecko sampling plot (Appendix A). Chew blocks were placed at any two opposite corners of each plot. No rat activity was detected on the chew blocks.

The use of chew blocks will also be included during each future gecko survey. If rats are found, the Service and the PRDNER will plan for an eradication effort as soon as possible.

### C. Habitat

As previously explained in this document, habitat threats were not considered at the time of listing (1982). In addition, there is no specific information regarding how habitat modification may have affected the species.

The first attempt to quantify habitat for the Monito gecko was during the May 2016 survey trip, but the habitat covariates as recorded (i.e. % shrub cover, % herbaceous cover, % ground cover, % leaf litter, and % canopy cover) could not explain the differences in gecko detection or abundance across the plots. Thus, it appears that unmeasured aspects of the environment affected abundance and detection of the Monito gecko.

Neither satellite images nor historic aerial photos are available or do not have the appropriate resolution to make a reliable habitat map for Monito Island. The use of unmanned aerial vehicles (UAVs) should be considered to obtain high resolution aerial photos of Monito Island in order to better quantify habitat variables. Any UAV use needs to consider current FAA regulations and potential effects to the seabird nesting colony in Monito Island.



#### **D. Practices to Assure Consistency of Data Collection**

Population and habitat monitoring methods are deliberately using the same methods used during the May 2016 survey (Island Conservation 2016). This will ensure data collection and analysis consistency, and allow comparisons to previous years' data which will also result in more accurate estimates of natural variability. The following practices will be followed in order to minimize variability that could be introduced by inconsistent sampling practices:

1. Post-delisting monitoring is a cooperative effort among the Service and the PRDNER.
2. Biologists and technicians will be properly trained in the needs and life history of the Monito gecko and in the implementation of the proposed survey.
3. Gecko and rat population monitoring will be conducted using the same methodology and in a manner consistent with the May 2016 survey results and recommendations.
4. Population reports will be submitted to the Service's Caribbean Ecological Services Field Office. Both the Service and the PRDNER will meet to jointly evaluate the report results and to discuss and develop any needed adjustments.

#### **E. Frequency and Duration of Monitoring**

The PDM period will be initiated during 2020. Given the logistical challenges of disembarking on Monito Island, the PDM should be implemented at least once every two years. Transportation, monitoring, data analysis, and other research may be contracted.

### **VI. Definition of Response Triggers for Potential Monitoring Outcomes**

Effective PDM requires timely evaluation of data and responsiveness to observed trends. In order to assure timely response to observed trends, it is necessary to identify possible outcomes from monitoring that could be anticipated and general approaches for responding to these scenarios. In order to identify thresholds that would trigger alternative responses in the case of the Monito gecko, it will be necessary to analyze data from the PDM period and the May 2016 survey, and to identify the range of variability that has been observed with respect to each of the variables that will be monitored during those surveys.

To measure specific Monito gecko population demographics would be challenging given the logistics and difficulty to disembark on the Island and stay there to complete any type of long-term research. In addition, the species is small, cryptic, and easier to detect at night. Thus, measures such as survival rates, predation rates, population growth rates, among others, may not be possible *in situ*.

Throughout the PDM period, the Service and the PRDNER will explore alternative study designs and data collection options for further improving or refining the PDM protocols. The PDM analysis will be used to assess the species' population persistence over that period. We will be able to categorize the results into one of the following PDM outcomes:

**A. Category I**

The Monito gecko population and habitat remain secure without the Act's protections. This would be true if:

1. Gecko abundance and occupancy should remain within the confidence interval of values observed during the May 2016 survey and/or future surveys; and,
2. The amount and quality of habitat remains stable or does not significantly decrease; and,
3. No new or increasing threats to the species are observed that are considered to be of a magnitude and imminence that may threaten the continued existence of the Monito gecko within the foreseeable future.

In this case, PDM would be concluded at the end of the timeframe specified in this Plan.

**B. Category II**

The Monito gecko population and habitat may be less stable than anticipated at the time of delisting, but information does not indicate that the species meets the definition of threatened or endangered. This would be true if:

1. Gecko abundance and occupancy remain within the lower bound of the confidence interval values observed during the May 2016 survey and/or future surveys; and,
2. The amount and quality of habitat has declined to a degree that negative impacts to the Montio gecko population are likely in the future if habitat trend continues; and,
3. There are no new or increasing threats that are considered to be of a magnitude and imminence that may threaten the continued existence of the Monito gecko within the foreseeable future.

In this case, the Service and the PRDNER will evaluate if the PDM period should be extended for an additional five years, and if necessary, sampling intensity could be increased to provide greater precision in detecting trends. Existing data will be analyzed to determine if any management actions should be implemented that would be expected to reverse declines and stabilize or improve population trends for the species.

### **C. Category III**

PDM yields substantial information indicating that threats are causing a decline in the status of the Monito gecko since the time of delisting, such that listing the species as threatened or endangered may be warranted. This may be true if:

1. Gecko abundance and occupancy falls below the lower bound of the confidence interval values observed during the May 2016 survey (i.e. 50% CI: 5,344 - 10,590); or,
2. The amount and quality of habitat has significantly declined to a degree that negative impacts to the Montio gecko population are evident in population survey results; or,
3. There are new or increasing threats that are considered to be of a magnitude and imminence that they could threaten the continued existence of the Monito gecko within the foreseeable future.

If any of these conditions is true, then the Service should initiate a formal status review to assess the changes in threats to the species to determine whether a proposal for relisting is appropriate. If all of these conditions are true, then the Service should promptly propose that the Monito gecko be relisted under the Act in accordance with procedures in section 4(b)(5).

## **VII. Data Compilation and Reporting Procedures**

Annual reports summarizing the PDM activities accomplished, data collected, and results will be submitted to the Service's Caribbean Ecological Services Field Office. These reports should be prepared in a timely manner in accordance with this Plan to ensure that adequate data are being collected, to allow evaluation of the efficacy of the monitoring program, and to provide a periodic assessment of the status of the Monito gecko. Each report will synthesize all the population monitoring data and comment on observed trends and status of the Monito gecko with respect to the PDM outcome categories presented in Section VI of this Plan. Reports are due each calendar year a survey is implemented and will include all data collected from the previous survey.

After at least 2 more surveys, we will review the available information to determine overall population change and status with respect to threats. We will compile the

annual report data into a final monitoring report that will be made available to the public. The final monitoring report will summarize the data in the annual reports. It will include a description of the areas surveyed, the survey protocol, and updated population numbers for Monito Island.

If the response triggers in Section VI above are met or exceeded, the Service will consult with the PRDNER, and other partners to determine whether to conclude the PDM process or to pursue alternative actions as described in Section VI. Our determination also will include, if necessary, an evaluation of the threats to the Monito gecko using the five factors required under the Act to list a species on the Federal List of Threatened and Endangered Wildlife and Plants.

## **VIII. Estimating Funding Requirements and Sources**

Post-delisting monitoring is a cooperative effort among the Service and the PRDNER. Other cooperators may also include other Federal agencies, universities, and other non-governmental partners and volunteers. Although the Act authorizes expenditures of both recovery funds and Section 6 grants to the States to plan and implement PDM, Congress has not allocated or earmarked any special funds for this purpose. To the extent feasible, the Service intends to provide funding for PDM efforts from annual Endangered Species Recovery Program appropriations. Nonetheless, nothing in this Plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act (31 U.S.C. 1341) or any other law or regulation.

Based on Service's costs associated with recovery monitoring efforts, annual PDM expenditures for the Service should not exceed \$60,000.

## **IX. PDM Implementation Schedule**

In order to maintain consistency, PDM surveys should be implemented preferably during the first week of May or sometime during April to June. Schedule will be developed in coordination with the PRDNER in order to ensure that it is feasible to accomplish the PDM activities. At least two PDM surveys should be completed within the next five years. Depending on the results, more PDM surveys can be considered. The PDM survey schedule is May 2018, 2020, and 2022.

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## XI. Appendices

### A. Monito Island with the 40 gecko survey plots (May 2016) and GPS coordinates of the southwest point of each plot.



PLOT #	Coordinate X	Coordinate Y	PLOT #	Coordinate X	Coordinate Y
1B	18.16012	-67.94935	26B	18.15967	-67.94759
2B	18.16037	-67.94916	27B	18.15882	-67.94951
3B	18.15968	-67.95077	29B	18.16077	-67.94986
5B	18.15952	-67.94855	31B	18.16075	-67.94785
6B	18.15861	-67.94735	33	18.15878	-67.94900
7	18.16076	-67.94923	34	18.15928	-67.94948
8B	18.15894	-67.94772	35B	18.16017	-67.94999
10	18.16053	-67.95005	36	18.15875	-67.94870
11	18.15993	-67.94827	37	18.16025	-67.94873
12	18.16086	-67.95007	39	18.16021	-67.94768
13B	18.15930	-67.95089	41B	18.16105	-67.94986
14	18.15978	-67.94792	42	18.15901	-67.94960
15	18.15996	-67.95015	44	18.15936	-67.94817
16B	18.15860	-67.94801	45B	18.15910	-67.95011
17	18.16051	-67.94858	46	18.16031	-67.94827
18	18.15855	-67.95022	47	18.16078	-67.94850
20	18.15915	-67.94840	48	18.15935	-67.94997
22	18.16055	-67.94887	50B	18.15891	-67.95087
23B	18.15989	-67.95069	51	18.15890	-67.94842
25	18.15840	-67.95095	52	18.15936	-67.94791

**B. Sample data sheets (repeat sheets for each individual plot survey).**

MONITO GECKO SURVEY						
GPS Coordinate	18.16075 / -67.94785					
DATE	May 6, 2016					
Start Time:	7:35	End Time:	7:55			
Plot #: 31B	Observer #1:	USFWS				
SURVEY #1						
Lizard	Time	Age & Size	Behavior	Habitat	GPS Coordinates N	GPS Coordinates W
1	7:37	Adult-missing tail tip	Alert	On exposed rock	18.16093	-67.94789
2	7:41	Sud-adult	Alert	Under rock	18.16091	-67.94774
3	7:44	Juvenile	Alert	On soil under canopy	18.16088	-67.94773

MONITO GECKO SURVEY						
DATE	May 6, 2016	Time Taken	Temperature (F)	Relative Humidity (% RH)	Average Wind Speed (MPH)	Max Wind Speed (MPH)
Weather	Clear Skies	7:15 PM	81.4	82.8	3.3	10
Weather	Clear Skies	12:00 AM	80.6	85.5	2.3	5
DATE	May 7, 2016	Hour Taken	Temperature (F)	Relative Humidity (% RH)	Average Wind Speed (MPH)	Max Wind Speed (MPH)
Weather	Cloudy, Light Rain	7:27 PM	84.2	79.2	2.2	6.1
Weather	Cloudy, Light Rain	10:05 PM	81.8	84.3	2.4	4.5
Plot #	% Shrub	% Herb	% Ground Cover	% Leaf Litter	% Canopy Cover	
11	60	15	25	0	1	



**C. Monito Island with the snap trap and chew block transects (May 2014).**

